SMOKY HILL/SALINE RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: Herington Reservoir
Water Quality Impairment: Eutrophication bundled with Dissolved Oxygen

Subbasin: Lower Smoky Hill

Counties: Dickinson and Marion

HUC 8: 10260008 **HUC 11** (14)**: 070** (010)

Ecoregion: Flint Hills (28)

Drainage Area: Approximately 24.4 square miles

Conservation Pool: Area = 500 acres
Watershed Area: Lake Surface Area = 31:1
Maximum Depth = 9.0 meters (30 feet)
Mean Depth = 3.2 meters (10 feet)
Retention Time = 1.0 year (12 months)

Designated Uses: Secondary Contact Recreation; Special Aquatic Life Support; Drinking Water; Food Procurement; Industrial Water Supply

Authority: City of Herington

2002 303(d) Listing: Smoky Hill/Saline River Basin Lakes

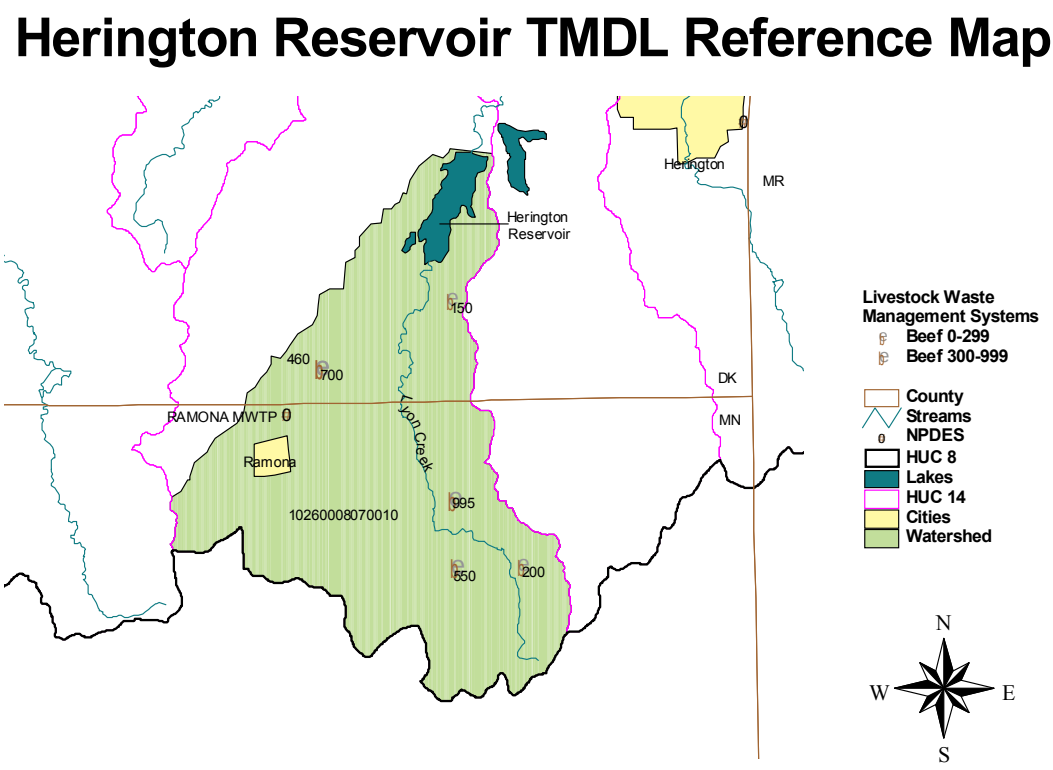
Impaired Use: All uses are impaired to a degree by eutrophication

Water Quality Standard: Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation. (KAR 28-16-28e(c)(7)(A)).

Dissolved Oxygen: 5 mg/L (KAR 28-16-28e(c)(2)(A))

Figure 1



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Very Eutrophic, Trophic State Index = 60.76

Monitoring Sites: Station 047201 in Herington Reservoir (Figure 1).

Period of Record Used: Fifteen surveys during 1987 - 2000

Current Condition: Over the period of record, Herington Reservoir has been very eutrophic. The lake had chlorophyll a concentrations averaging 21.7 μg/L, a Total Phosphorus concentration of 69 μg/L, a Total Kjeldahl Nitrogen concentration of 1.00 mg/L, a nitrate concentration of 0.10 mg/L, and a nitrite concentration of 0.06 mg/L (Appendix A). Light was indicated to be the primary limiting factor due to clay turbidity (Appendix B). Nitrogen was a secondary limiting factor. The chlorophyll a to total phosphorus yield was moderate.

The Trophic State Index is derived from the chlorophyll a concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll a concentrations,

nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll a concentrations over 7 μg/l and hypereutrophy occurs at levels over 30 μg/l. The Carlson TSI, derives from the chlorophyll concentrations and scales the trophic state as follows:

1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: ≥ 64

Decomposition of plant material has lowered the dissolved oxygen concentrations in the lake. The dissolved oxygen concentrations decreased with increased depth. (See the table below). At the surface, the average concentration was 9.0 mg/L, a sufficient amount of dissolved oxygen for aquatic life support. In 1995 and 1996, near the mean depth of the lake, the concentration dropped below the Water Quality Standard to 4.7 mg/L. Of concern is the expansion upward of the low dissolved oxygen zone in recent years, suggesting the accumulation of organic matter in the lake.

Dissolved Oxygen Concentrations in Herington Reservoir

Start Date	Sample Depth (feet)	Dissolved Oxygen (mg/L)
06/29/87	0	7.60
06/29/87	1.64	7.50
06/29/87	3.28	7.50
06/29/87	6.56	7.50
06/29/87	9.84	7.50
06/29/87	13.12	7.40
06/29/87	16.4	7.40
10/01/90	0	10.40
10/01/90	1.64	10.40
10/01/90	3.28	10.40
10/01/90	6.56	10.40
10/01/90	9.84	10.10
10/01/90	13.12	9.80
10/01/90	16.4	6.80
10/01/90	19.68	6.20
10/01/90	22.96	5.90
10/01/90	26.24	**4.00**
04/01/91	0	14.00
04/01/91	1.64	14.00
04/01/91	3.28	14.00
04/01/91	6.56	14.00
04/01/91	9.84	14.00
04/01/91	13.12	13.80
04/01/91	16.4	13.40
04/01/91	19.68	11.40

05/06/91	0	8.80
05/06/91	1.64	9.80
05/06/91	3.28	9.80
05/06/91	6.56	10.00
05/06/91	9.84	10.20
05/06/91	13.12	10.20
05/06/91	16.4	10.20
05/06/91	19.68	10.00
05/06/91	22.96	9.80
05/06/91	24.6	**2.00**
06/03/91	0	9.60
06/03/91	1.64	9.70
06/03/91	3.28	9.70
06/03/91	6.56	9.70
06/03/91	9.84	9.70
06/03/91	13.12	9.60
06/03/91	16.4	7.90
06/03/91	19.68	9.70
06/03/91	22.96	**1.40**
07/08/91	0	8.60
07/08/91	1.64	8.70
07/08/91	3.28	8.40
07/08/91	6.56	8.00
07/08/91	9.84	8.20
07/08/91	13.12	7.20
07/08/91	16.4	6.40
07/08/91	19.68	6.20
07/08/91	22.96	5.00
07/08/91	26.24	**4.20**
08/05/91	0	9.60
08/05/91	1.64	9.40
08/05/91	3.28	8.70
08/05/91	6.56	6.20
08/05/91	9.84	6.20
08/05/91	13.12	6.20
08/05/91	16.4	6.60
08/05/91	19.68	5.80
08/05/91	22.96	5.40
08/05/91	26.24	**1.80**
09/03/91	0	7.90
09/03/91	1.64	8.70
09/03/91	3.28	8.50
09/03/91	6.56	6.00
09/03/91	9.84	5.80
09/03/91	13.12	5.40
09/03/91	16.4	**1.80**
09/03/91	19.68	**0.30**
09/03/91	22.96	**0.00**
10/07/91	1.64	9.20

06/20/94	0	10.20
06/20/94	1.64	10.20
06/20/94	3.28	10.20
06/20/94	6.56	9.80
06/20/94	9.84	10.00
06/20/94	13.12	**4.00**
06/20/94	16.4	**2.40**
06/20/94	19.68	**0.60**
06/20/94	22.96	**0.50**
06/20/94	26.24	**0.30**
08/22/94	0	7.20
08/22/94	1.64	7.20
08/22/94	3.28	7.10
08/22/94	6.56	7.10
08/22/94	9.84	7.10
08/22/94	13.12	7.10
08/22/94	16.4	7.10
08/22/94	19.68	7.00
08/22/94	22.96	6.80
08/22/94	26.24	6.50
08/22/94	29.52	**2.20**
08/21/95	0	6.60
08/21/95	1.64	6.60
08/21/95	3.28	6.60
08/21/95	6.56	5.30
08/21/95	9.84	**4.90**
08/21/95	13.12	**4.80**
08/21/95	16.4	**4.70**
08/21/95	19.68	**4.20**
08/21/95	22.96	**3.20**
08/21/95	26.24	**2.20**
08/21/95	27.88	**1.80**
07/02/96	0	9.60
07/02/96	1.64	9.80
07/02/96	3.28	9.60
07/02/96	6.56	**4.80**
07/02/96	9.84	**4.40**
07/02/96	13.12	**3.80**
07/02/96	16.4	**3.60**
07/02/96	19.68	**2.70**
07/02/96	22.96	**0.60**
07/02/96	26.24	**0.00**
07/10/00	0	6.20
07/10/00	1.64	6.20

Interim Endpoints of Water Quality (Implied Load Capacity) at Herington Reservoir over 2008 - 2012:
In order to improve the trophic condition of the lake from its current very Eutrophic status, the desired endpoint will be to maintain summer chlorophyll a concentrations below 12 μg/L. Achievement of this endpoint should also result in dissolved oxygen concentrations above 5 mg/L.

Total Nitrogen concentration in the lake should be maintained below 0.62 mg/L. A regression of 2000 - 2001 lake data and 1997 - 2000 wetland data was used to determine the current, in-lake nitrogen concentration and to calculate how much of a nutrient reduction was need to meet water quality standards.

Current Condition and Reductions for Herington Reservoir

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Load (lb/year)	15,715	5,138	67 %
Total Phosphorus Concentration (μg/L)	69	35	49 %
Chlorophyll a (μg/L)	21.7	< 12	45 %
Total Nitrogen Concentration (mg/L)	1.17	< 0.62	47 %

3. SOURCE INVENTORY AND ASSESSMENT

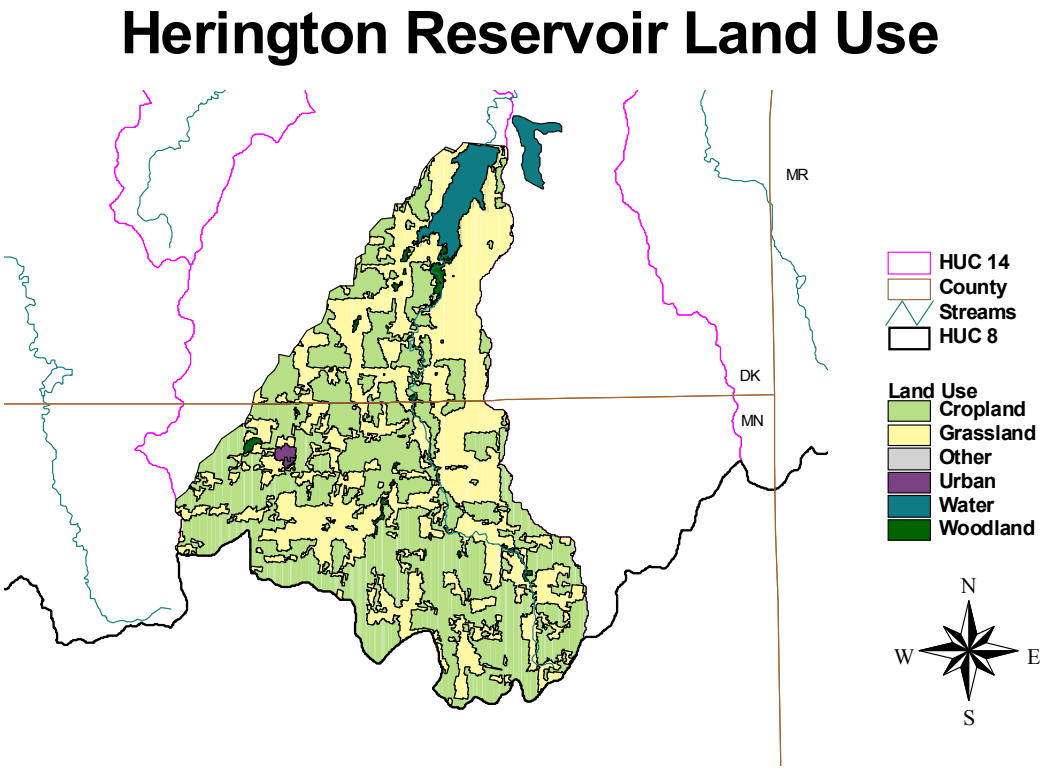
NPDES: One permitted waste treatment facility is located within the watershed (Figure 1). Ramona Municipal Wastewater Treatment Plant (Kansas Permit Number: M-SH30-NO01) is a non-overflowing lagoon that is prohibited from discharging and may contribute a nutrient load under extreme precipitation events (flow durations exceeded under 5 percent of the time).

Land Use: The watershed around Herington Reservoir has a moderate potential for nonpoint source pollutants. An annual phosphorus load of 15,715 pounds per year is necessary to correspond to the concentrations seen in the lake.

One source of phosphorus and nitrogen within Herington Reservoir is probably runoff from agricultural lands where phosphorus and nitrogen have been applied. Land use coverage analysis indicates that 51.7% of the watershed is cropland (Figure 2).

Phosphorus and nitrogen from animal waste are a potential contributing factor. Animal waste, from livestock waste management systems, may add to the phosphorus and nitrogen loads going into the lake. However, given the controls for the systems, animal waste coming from grazing areas is a more likely contributor. Forty-four percent of land around the lake is grassland. There are six beef animal feeding operations in the watershed. All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25 year, 24 hour rainfall/runoff event,

which would be indicative of flow durations well under 10 percent of the time. In Dickinson County, such an event would generate 5.8 inches of rain, yielding 4.7 to 5.4 inches of runoff in a day. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units. The facilities in this watershed are not of this size. Potential animal units for these facilities in the watershed total 3,055. The actual number of animal units on site is variable, but typically less than potential numbers. **Figure 2**



The City of Ramona is expecting a 6.4% population decline to the year 2020. The population density within the watershed is 6.9 people per square mile. Less than one percent of the watershed is urban. Stormwater runoff and urban fertilizer applications are a minor contributing factor. Twenty-nine percent of the homes in Dickinson County have septic systems. Septic systems around the lake contribute to the nutrient load.

Contributing Runoff: The watershed's average soil permeability is 0.5 inches/hour according to NRCS STATSGO database. About 100% of the watershed produces runoff even under relatively low (1.5''/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 14.2% of this watershed, chiefly along the stream channels.

Background Levels: The atmospheric phosphorus and geological formations (i.e., soil and bedrock) may contribute to phosphorus loads. Nutrients from wildlife waste are another contributing factor.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

While light is the limiting factor in Herington Reservoir, Total Phosphorus is allocated under this TMDL, because a phosphorus reduction will have a large effect on the managing the algal community. The Load Capacity is 5,138 pounds per year of phosphorus and was calculated using the CNET model. More detailed assessment of sources and confirmation of the trophic state of the lake must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction. Because of atmospheric deposition, initial allocations of nitrogen will be based on a proportional decrease in nitrogen between the current condition and the desired endpoint.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers. As previously noted in the inventory and assessment section, sources such as non-discharging permitted municipal facilities and livestock waste management systems located within the watershed do not discharge with sufficient frequency or duration to add to an impairment in the lake.

Nonpoint Sources: Water quality violations are partially due to nonpoint source pollutants. Background levels may be attributed to atmospheric deposition and geological sources. The assessment suggests that cropland and animal waste contribute to the elevated total phosphorus concentrations in the lake. Generally a Load Allocation of 4,624 pounds of total phosphorus per year, leading to a 67% reduction, is necessary to reach the endpoint. A proportional decrease of 42% in nitrogen loading will allow the total nitrogen endpoint to be achieved.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus load and the chlorophyll a endpoint. Therefore, the margin of safety will be 514 pounds per year of total phosphorus taken from the load capacity subtracted to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. For nitrogen, the margin of safety will be an additional 5% reduction in nitrogen to ensure that the endpoint is reached.

State Water Plan Implementation Priority: Because Herington Reservoir is used for drinking water and a substantial amount of sampling has been done, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: Herington Reservoir lies within the Lower Smoky Hill (HUC 8: 10260008) with a priority ranking of 35 (Medium Priority for restoration).

Priority HUC 11s: Since it encompasses the entire Herington Reservoir watershed, the HUC 11 (10260008070) should take priority.

5. IMPLEMENTATION

Desired Implementation Activities

There is a very good potential that agricultural best management practices will allow full use support to take place in Herington Reservoir. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure application to land.

Implementation Programs Guidance

Nonpoint Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management

b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.

c. Provide technical assistance on nutrient management in vicinity of streams.

d. Update and implement nutrient and sediment abatement strategies.

e. Develop a Watershed Restoration and Protection Strategy for HUC 10260008.

Water Resource Cost Share Nonpoint Source Pollution Control Program - SCC

a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.

b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.

b. Develop riparian restoration projects.

c. Promote wetland construction to assimilate nutrient loadings.

Buffer Initiative Program - SCC

a. Install grass buffer strips near streams.

b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

a. Continue to educate residents and landowners about nonpoint source pollution.
b. Educate agricultural producers on sediment, nutrient, and pasture management.
c. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
d. Provide technical assistance on livestock waste management systems and nutrient management plans.
e. Provide technical assistance on buffer strip design and minimizing cropland runoff.
f. Encourage annual soil testing to determine capacity of field to hold phosphorus.

Time Frame for Implementation: Pollutant reduction practices should be installed within the priority subwatersheds during the years 2003-2008, with minor followup implementation, including other subwatersheds over 2008-2012.

Targeted Participants: Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in 2003 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

1. Total row crop acreage
2. Cultivation alongside lake
3. Drainage alongside or through animal feeding lots
4. Livestock use of riparian areas
5. Fields with manure applications

Milestone for 2008: The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Herington Reservoir should indicate evidence of reduced phosphorus and nitrogen levels in the conservation pool elevations relative to the conditions seen in 1987-2000.

Delivery Agents: The primary delivery agents for program participation will be conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Smoky Hill/Saline Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a High Priority consideration.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming and installation of buffer strips within the watersheds cited in this TMDL.

6. MONITORING

Additional data, to further determine source loading and mean summer lake trophic condition, would be of value prior to 2008. Further sampling and evaluation should occur once before 2008 and twice between 2008 and 2012. Some monitoring of tributary levels of nutrients will help direct abatement efforts toward major contributors.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Smoky Hill/Saline Basin were held January 7 and March 5, 2003 in Hays. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Smoky Hill/Saline Basin.

Public Hearing: A Public Hearing on the TMDLs of the Smoky Hill/Saline Basin was held in Hays on June 2, 2003.

Basin Advisory Committee: The Smoky Hill/Saline Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 5, and June 2, 2003.

Milestone Evaluation: In 2008, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Herington Reservoir. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

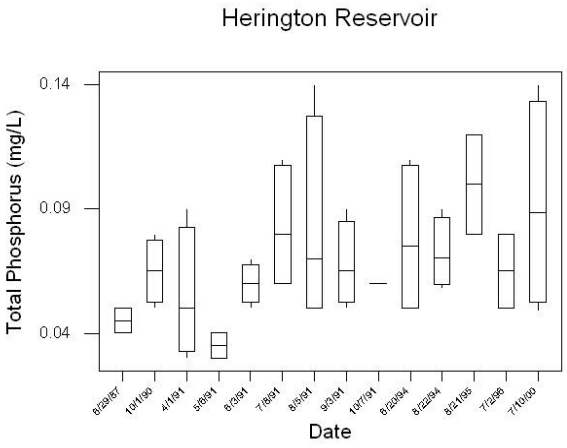
Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

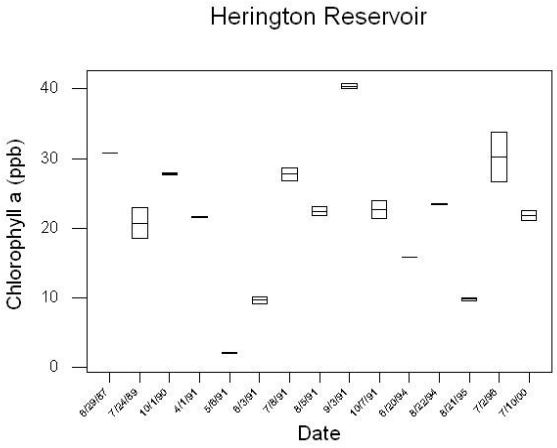
Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2004 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2004-2008.

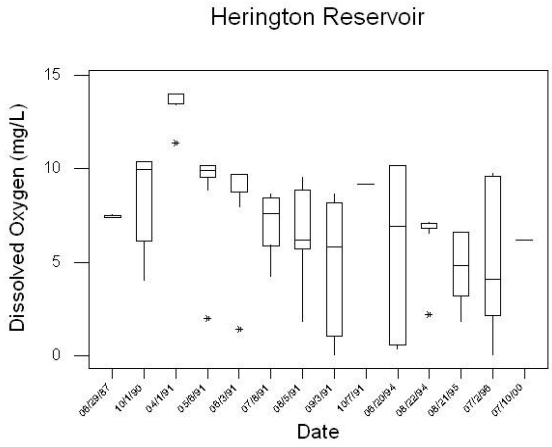
Bibliography

Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001; http://www.kdhe.state.ks.us/tmdl/eutro.htm [Accessed 30 September 2002].

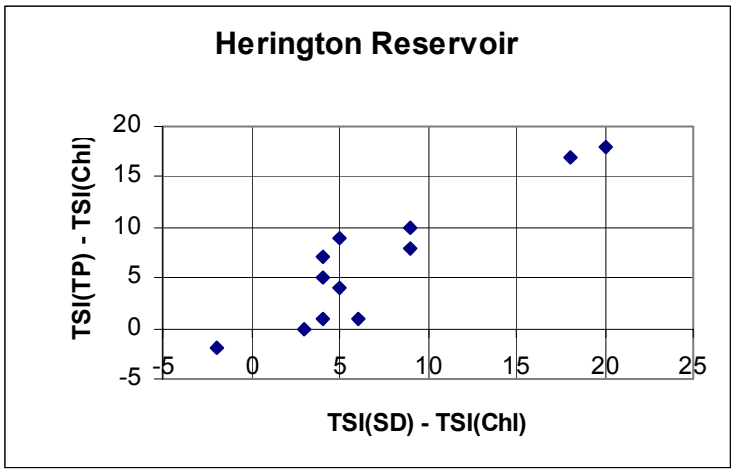
Appendix A - Boxplots

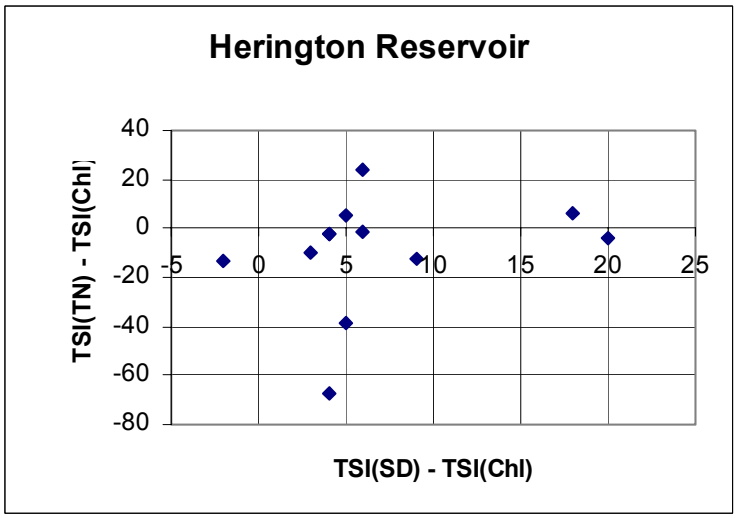






Appendix B - Trophic State Index Plots





The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD) - TSI(Chl) and TSI(TP)-TSI(Chl). The deviation of chlorophyll from the sediment load indicates the degree of light penetration, while the difference between chlorophyll and phosphorus indicates the level of phosphorus limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus does not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles. The relationship between the TSI(SD) - TSI(Chl) and TSI(TN)-TSI(Chl) indicates that nitrogen may be a secondary limiting factor.

Appendix C - Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (km^2)	63.17
Precipitation (m/yr)	0.77
Evaporation (m/yr)	1.4
Unit Runoff (m/yr)	0.14
Surface Area (km^2)	2.02
Mean Depth (m)	3.2
Depth of Mixed Layer (m)	3.2
Depth of Hypolimnion (m)	0.9
Observed Phosphorus (ppb)	68.8
Observed Chlorophyl-a (ppb)	21.7
Observed Secchi Disc Depth (m)	0.7

Output from CNET Model

Parameter	Output from CNET Model
Load Capacity (LC)*	**5,138 lb/yr**
Waste Load Allocation (WLA)	**0 lb/yr**
Load Allocation (LA)	**4,624 lb/yr**
Margin of Safety (MOS)	**514 lb/yr**

***LC = WLA + LA + MOS**

Approved Aug. 7, 2003